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HISTORY OF THE MARK 4 BOMB (U)

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HISTORY OF THE MARK 4 BOMB (U)

This history recounts the reasons why the Mark 4 Bomb was needed, and tells the story of its design and development in broad outline.

Information Research Division, 3434

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HISTORY OF THE MK 4 BOMB

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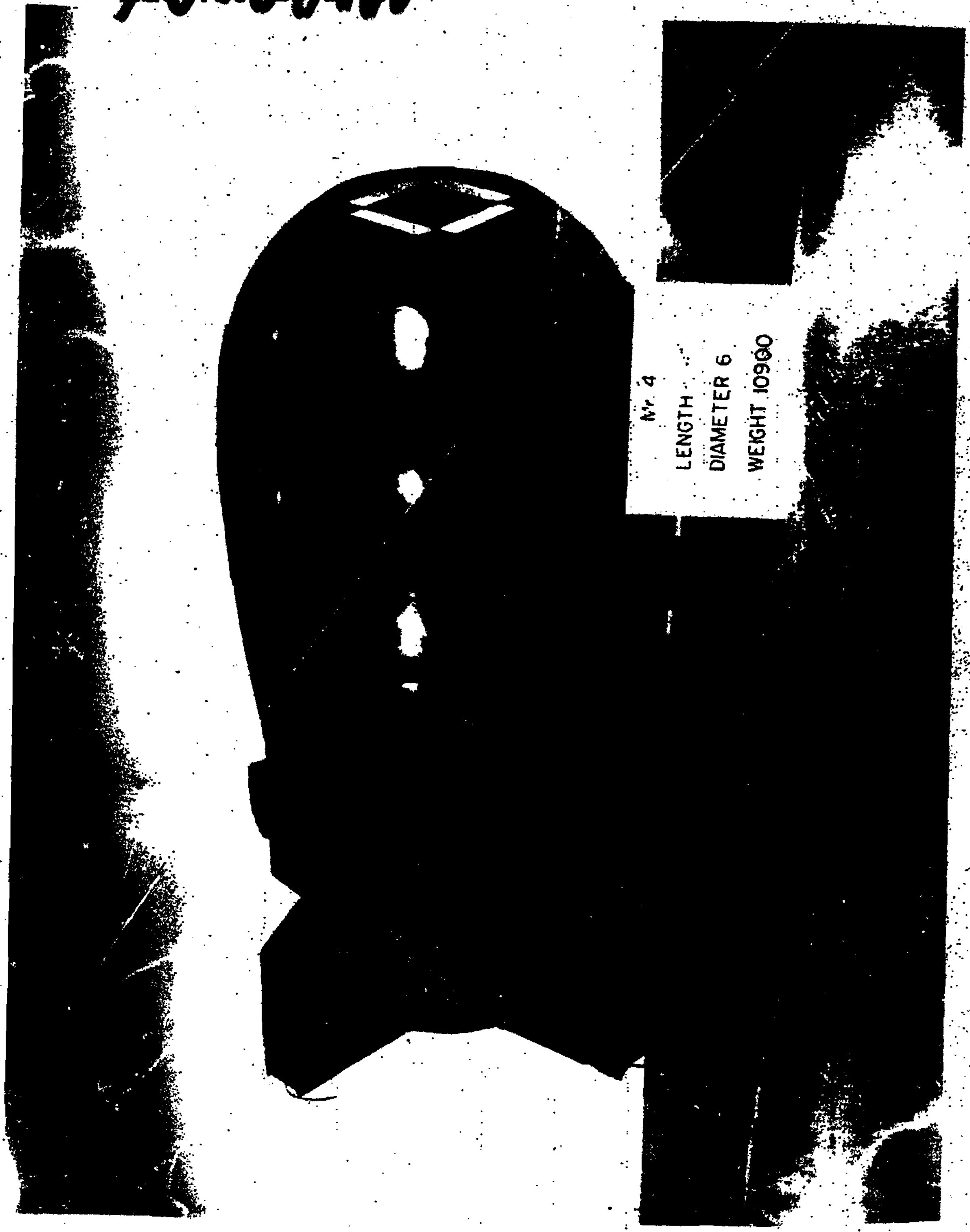

Figure 1. Mk 4 - Exterior View

Figure 2. Comparison of [redacted] Shape of Mks III and 4

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Figure 4. Nuclear Insertion -- On Ground

An original version of the ground insertion process. The tripod was removed before the bomb was installed in the plane.

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Figure 5. Nuclear Insertion -- Inflight

Inflight insertion version. Baskets to hold the high-explosive sphere segments; arms to hold the nose plate and polar cap.

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TIMETABLE OF MK 4 EVENTS

Early 1945	Initial consideration of weapon.
8/2/45	Z Division of the Los Alamos Laboratory organized - Mk 4 development started.
9/27/45	Z-Division representatives started move to Sandia Base.
9/28/45	Issuance of Z-Division progress reports begun.
10/4/45	Mk 4 schedule defined.
12/14/45	Initial practice drop made at the Los Lunas Bombing Range.
7/46	Operation Crossroads at Bikini Atoll - Mk 4 development interrupted.
8/1/46	Atomic Energy Act passed.
2/47	Z Division consolidated at Sandia Base.
4/4/47	First half-scale Mk 4 drops conducted at Salton Sea Test Base.
3/2/48	Sandia Research and Development Board organized.
4/1/48	Z Division becomes Sandia Branch, Los Alamos Scientific Laboratory.
Mid-1948	Operation Sandstone at the Eniwetok Atoll - Mk 4 development delayed.
1/15/49	Mk 4 Preliminary Evaluation Report issued.
3/19/49	Mk 4 weapon enters stockpile.

Chapter I - The Design Task

The Mk 4 weapon was the first atomic bomb to be designed as a practical piece of ordnance as contrasted to a laboratory device that would function properly only when assembled and used by highly trained personnel under closely controlled conditions. The initial approach to this bomb was made early in 1945, shortly after the wartime ordnance designs were frozen. At this time, the implosion-type weapon (which had been initially called the 1561 after its Los Alamos drawing number) had been code-named the Fat Man in recognition of its outer shape, which possessed a distinct midriff bulge. Various designs of the Fat Man were subsequently assigned Mark nomenclature, but there is some question as to the precise definition of either the Mk I or the Mk II designs. The version of the Fat Man that was manufactured and stockpiled after the end of the War (to the basic wartime design) was called the Mk III.[1]

There were several reasons why it was necessary to redesign the Mk III. In addition to the desire to create a practical piece of ordnance--one that could be used in combat by a military team of average training and capabilities--it was hoped to develop better manufacturing and assembly techniques and to clean up marginal ballistic and vibration characteristics, in the interests of improving bombing accuracy. The weapon that eventually evolved from these redesign efforts was for a time called the Mk IV Fat Man, but toward the end of the program the Roman numeral was replaced by the Arabic number 4, and herein we will generally refer to the weapon as the Mk 4.

Initially, consideration was given to design and manufacture of various ballistic or external shapes, investigation of internal pressures within the high-explosive sphere, redesign of detonators for easy installation,

[redacted]

and the proper number of high-explosive lenses for efficient implosion. These studies, at first carried out in different parts of the Los Alamos Laboratory, were consolidated in one organization August 2, 1945, when the Z Division of the Laboratory was created to carry on activities of ordnance design and delivery of atomic bombs. Jerrold Zacharias, who had been active in the radar group of the Massachusetts Institute of Technology Radiation Laboratory, was selected to head this new organization, the Z nomenclature stemming from the first letter of his last name.

The broad area of responsibility of the new Division was indicated in a memorandum dated August 6, 1945, from Dr. Zacharias to J. Robert Oppenheimer, Director of the Los Alamos Laboratory. In part, the memorandum read:

> "With the organization of Z Division in such a fluid state, it is tempting to put nothing on paper. The Division is likely to become larger and to take on so many duties of so many different divisions that a more vertical organization than is usual in Project Y [Los Alamos] will have to be sought."

Dr. Zacharias then proposed an organizational breakdown of the Division, with work assignments as follows:

Z-1, Experimental Systems Engineering, to perform airborne testing, ballistics, aerodynamics, radar, and informer or telemetering work.

Z-2, Assembly Factory and Procurement, to procure, assemble, and ship weapons.

Z-3, Electrical Engineering, to design firing circuits and detonators.

Z-4, Mechanical Engineering for Production, to be concerned with general engineering changes, and--most pertinent to this history--the "coordination of development of streamlined gadget" (i.e., the Mk 4).

Z-5, Electronic Engineering, to handle fuze development.

Chapter II - Early Development

It now became necessary to provide adequate space and facilities for the work of the Z Division. The first step in this direction was taken in the fall of 1945, when the Engineering Division of Los Alamos was requested to design a testing laboratory. This laboratory would simulate on the ground the conditions which bombs and components experienced in flight. This testing laboratory was subsequently built and proved of material assistance in the development of the new weapon.

Meanwhile, a proper work location for the assembly group, Z-2, was being discussed. This organization, which was largely staffed with military and Civil Service personnel, could be administratively separated from the rest of the Division, and required an area convenient to air and rail transportation. A logical spot was the former Oxnard Field, the original Albuquerque Airport (now called Sandia Base), which already was the property of the Manhattan Engineer District, having been obtained in July 1945 for the never-consummated objective of providing space for temporary storage of atomic-bomb materiel during World War II. A meeting was held at Sandia August 29, 1945, at which time it was decided to transfer Z-2 to Sandia Base. It was also decided to remove the W-47 Flight Test Group from Wendover Field, Utah, and bring some of these personnel to Sandia Base.[4] After further discussion, it was decided that weapons production and test activities would be concentrated at Sandia and design work at Los Alamos.[5]

The first Z-Division representatives moved from Los Alamos to Sandia Base September 27, 1945, and on the following day Dr. Zacharias inaugurated the practice of issuing monthly progress reports.[6] The initial report of the Mechanical Engineering Group, Z-4, noted that work on the Fat Man was directed toward making this bomb a more reliable and serviceable weapon--more of a re-engineering task than a radical redesign of the entire gadget.

("Gadget" was a common term in those days for an atomic device.) The report pointed out that the Mk III had to be assembled component by component, while it was hoped that the new bomb could be put together in fairly large subassemblies In line with this objective, a start had been made in consolidating some of the electrical items into a "cartridge" that could be inserted into the weapon as a unit (in the same manner that a cartridge was inserted in the chamber of a rifle).

A conference between military and Z-Division personnel had meanwhile been held at Wright Field, Ohio, September 21, 1945, to review aircraft capable of carrying the proposed bomb. The B-36 long-range bomber was in the last phases of design and was nearing the flight-test stage, and several jet-propelled medium bombers were being developed. However, the B-36 had a relatively low top speed, and the jet bombers (at that time) were restricted in range, so it was concluded that any immediate redesign of the Fat Man must, of necessity, keep the B-29 in mind as the delivery vehicle.[7]

A Mk 4 planning meeting was held October 4, 1945, at which an optimistic schedule was laid out. The coefficient of expansion of the high-explosive sphere was to be determined by November 1, 1945. The external shape of the bomb and the elements of the firing circuitry were to be settled by December 1, and the sphere assembly and mounting were to be designed by December 15. Drawings of the tail, the cartridge, and the electrical equipment were to be prepared by January 1, 1946. Handling equipment was to be available by February 1; full-scale drops were to be started March 15; a pit and sphere assembly was to be completed by May 15; and the entire bomb was to be ready for stockpile production, with all problems solved, by July 1, 1946. (b)(3)

It is obvious ... that the

estimated date of July 1 for the completed bomb is contingent on the progress made with the pit."[6] However, it was understood that, should the nuclear design be produced, the weapons hardware group was to be ready with the rest of the bomb, and the Z Division swung into high gear.

During design of the wartime Fat Man, there had not been enough time to make a thorough analysis of component functions and their relationships to the overall weapon system. A study was thus started, covering the circuit elements of the bomb and the part played by such factors as simultaneity of switch operation in overall efficiency. Ballistic problems, further described in Chapter III, also were examined. To meet this need, a field-test range was secured, arrangements made for wind-tunnel work, and special telemetry apparatus started into design.

Improvements were made to various elements of the firing system, notably the X-unit, which created the high-voltage surge of current that fired the weapon detonators. The wartime implosion bomb had been equipped with an X-unit whose capacitors were charged to approximately 5600 volts before the bomb was released from the carrying airplane. This not only created a hazard to the bomber crew, but made it necessary to pressurize the X-unit to prevent internal arcing at bomb release altitudes. A safer and simpler X-unit was designed, which was charged after the bomb had fallen to its fuzing altitude, a safe distance from the strike aircraft.

Detonators were modified for easier installation, and much attention was paid to the design of segment molds and the lenses for most efficient implosion of the high-explosive sphere. Extensive tests were made of face pressures between high-explosive segments, and studies were conducted of improved systems of detonator cabling. The protruding Mk III (Yagi) antennas were redesigned to be recessed into the flattened nose of the bomb, thus simplifying weapon handling. So-called "Dipsy-Doodle" flight tests were conducted to determine the effects of signal interruption on the fuzing and firing system, and minor improvements were made to radar units and to the clock box circuits.[6]

The entire Division compiled lists of needed personnel and prepared plans for anticipated space at Sandia and Los Alamos. Many Division members were military representatives of the Special Engineer Detachment of the Manhattan Engineer District that had been formed to assist Los Alamos scientific personnel during the war, and efforts were made to interest these people in transferring to the Z Division in a civilian capacity.

This acceleration of effort continued for several months, only to be slowed down (in the design area) by many circumstances. One of these was Operation Crossroads, the first postwar full-scale test of atomic bombs. This operation took place at Bikini in July 1946, and many people from the Z Division were assigned in the early months of the year to help with the work. A second factor was loss of supervisory personnel. As an example, Dr. Zacharias returned to the Massachusetts Institute of Technology on September 28, 1945 (to be succeeded by Roger S. Warner, Jr., previously in charge of Z-2B, "Production Schedules and Manuals").[6] This was the first of many such moves, as in the next 15 months, 8 out of 10 Z-Division supervisors were to leave and be similarly replaced. A third item was the loss of trained military personnel as postwar demobilization got under way in early 1946 and career officers were returned to prewar commands. Finally, the lack of specific directives for new bomb design and production, and the general dearth of needed facilities impaired the progress of the overall work.

[redacted]

When the Crossroads contingent returned to the Division in the late summer of 1946, work on the Mk 4 was resumed, although at a somewhat slower pace. The Crossroads test had included an atomic device detonated under water, and the success of this explosion against target ships resulted in a demand for a penetrating weapon. The work on this latter device resulted in manpower being diverted from the Mk 4 program.

The passage of the Atomic Energy Act, August 1, 1946, resulted in cancellation by the Military of plans for Sandia buildings and facilities. The newly created Atomic Energy Commission could not immediately act to counter this cancellation, and securing needed space for the Mk 4 effort was delayed. Supply problems were aggravated as a result of the physical separation of parts of the Division from Los Alamos, with the Z-Division Progress Report of October 1946 noting that daily operations were "continually hampered by an inadequate supply of the common every-day types of electrical equipment ... such things as ordinary rosin solder, hook-up wire, etc."[6]

The need for this new weapon was, however, becoming more apparent, with the Division Leader reporting on November 29, 1946: "As we reach the end of the 1561 FM stockpiling program ... we are finding more and more subassemblies which are marginal .... In certain cases where we have taken steps to bolster one weakness, another develops, and so on ad nauseam until we reach the stage where by physical handling and reworking the component is worn out before it reaches the stockpile .... Because of the low confidence I have in the 1561 gadget, I request the Tech Board to permit me to carry through with the Mk IV test program under forced draft."[8]

Consequently, by early 1947, work was again moving forward and progress could be noted.[9] A full-size Mk 4 prototype shape was built and used in the design of handling equipment. The Z-4 group was moved from Los Alamos to Sandia Base, thus consolidating the entire Division at one location.

Mr. Warner became the AEC's first Director of Engineering and was replaced as head of the Z Division by Robert W. Henderson of Z-4. The Armed Forces Special Weapons Project was created to handle military functions relating to atomic energy, with an office being established on Sandia Base to provide liaison with the Z Division.

A date of March 15, 1948, was agreed to at a meeting of Z-Division supervisors on April 16, 1947, for a "proven Mk IV bomb ready to be procured in quantity by Road." (Road was a general code term for production and stockpiling activities, as the fact that the Division was producing atomic weapons was highly classified.) The meeting report also noted: "A tremendous responsibility has been given to Z Division to have this bomb by the above deadline because either the Mark IV is ready by that date or all work must cease and a new project along different lines must begin." (Official recognition was thus taken of approaching new weapons programs.) All groups were requested to determine their manpower needs and to make a realistic estimate of any additional personnel required, "realizing that even after the people have been found, a 45-day delay for clearance will follow."[10]

New employees subsequently were added to the Division. The cartridge design was completed and started into production. A thorough study was made of the proper location of detonator cabling. The sphere design was completed, and the assembly of the sphere to the outer case was checked out. Investigation was made of barometric switch operation, including the proper location of external ports in the outer case to provide pressure sensing as the bomb fell toward the target. It became necessary to seal the outer case to control this pressure sensing, and different sealing methods were proposed and tested. Handling equipment and storage containers were designed and built.

specifications, was issued January 15, 1949. A crash program produced test and handling equipment for military training and for possible emergency use.[20] As a result of this intensive effort, the first Mk 4 Bomb entered stockpile March 19, 1949.[21]

Field; and to confer with aerodynamicists and ballistics experts. They were informed that the best tail was a design using four equally spaced airfoils, and that these airfoils had to extend some distance out from the body of the bomb since, at high velocities, the air flow broke away from the bomb contour at approximately the maximum diameter of the bomb. It was felt unwise to permit the velocity of the bomb to exceed Mach 1 (the speed of sound), due to buildup of vibration, and it was suggested that a tail shroud be used to retard the rate of fall of the bomb if this velocity was approached in full-scale drops. The use of a blunt rather than a round nose was recommended in an effort to further retard the rate of fall.

A wind-tunnel test program was outlined, to be conducted at Aberdeen. Body shapes without tails would be initially investigated, and the best shapes fitted with simple fins and tested further. If these designs were not completely stable, a circular tail shroud would be added. These wind-tunnel tests would be made at speeds expected to be encountered in actual drops, and stability of the bomb shapes at higher or supersonic speeds would be checked by firing 20-millimeter-diameter models from a gun. It was felt that little could be done to improve the body of the bomb, due to the dimensional limitations imposed by high-explosive sphere and bomb bay, and that efforts should be concentrated on tail modifications.[22]

It had been decided to start full-scale test drops as soon as possible, and an aerial survey of World War II practice ranges in the vicinity of Albuquerque was made September 19, 1945, by members of Z-1. As a result, Range S-1 (which was renamed the Los Lunas Range) was selected for use. This range was located west of the town of Los Lunas and approximately 25 miles southwest of Albuquerque.[23]

In preparation for the work at Los Lunas, recording and communications gear was installed in trailers which could be based at Albuquerque and less yaw in flight than the standard fin. Fairly consistent performance was also obtained using a thin fin (with a plan area decreased approximately 25 percent) and a circular shroud. Neither of these two types, however, gave completely satisfactory ballistic performance.[27]

Members of the Armed Forces Special Weapons Project suggested that a group of aerodynamicists might be able to suggest improvements in ballistic characteristics, inasmuch as a great deal had recently been learned concerning actions of bodies passing through the transonic region, which had been pierced by manned aircraft only a few months previously. Consequently, representatives of Northrop, Rand, Douglas, North American, Boeing, Wright-Patterson Air Force Base, Inyokern, and Aberdeen formed an advisory panel which initially met May 26 and 27, 1948. The panel suggested that thin fins with flat sides and wedge cross sections would perform better than fins with curved sides and airfoil cross sections. It was also proposed that the planform of the fin be enlarged and drag introduced by the use of plates or spoilers to hold the velocity of the bomb below the transonic range. Arrangements were made to use the Cooperative Wind Tunnel at the California Institute of Technology, which had a greater velocity range than the Aberdeen tunnel.[28]

The flat-sided wedge fins were subsequently tested at the Cooperative Wind Tunnel and exhibited good stability.[22] Consistently good results were obtained from drop tests and, in mid-September 1948, the large-plan wedge fin was tentatively selected for use.[29,30] Detailed results of tests at the Cooperative Wind Tunnel became available October 1, 1948, and confirmed the results noted above. Perforated tail plates were tested on two bombs; one with a square plate and the other circular. The first gave improved control over pitch and yaw, while the second resulted in decreased control--hardly a conclusive test.

[redacted]

Since there was now a limited amount of time and drop tests that could be made, it was decided to concentrate on trials of a large-plan wedge, a thin-fin shroud wedge, a dorsal wedge, and a large plan with a sloping leading edge. All these, it was felt, would have about the same ballistic characteristics. A closer examination of wind-tunnel data subsequently narrowed the choice to a large-plan wedge or a thin-fin shroud wedge. It was then found that the reliability of the thin-fin shroud declined in high-speed, high-altitude drops, whereas the large-plan wedge did not, and the latter design became the obvious choice.

Aberdeen wartime experience with certain experimental bombs had indicated that a "flap" placed at the rear of a bomb shroud (which presented a greater angle of attack to the approaching air than the fin) would help to stabilize bomb flight, and large-plan wedge and thin-fin shroud tails were prepared with this modification. The first to be dropped was the large-plan wedge. One drop showed such excellent flight characteristics--with pitch and yaw of only about 2-1/2 degrees and a ballistic velocity coefficient only slightly lower than that of the thin-fin shroud--that it was deemed advisable to concentrate on further drops of this type, rather than expending time and energy on the thin-fin shroud, which was difficult to fabricate.[22] Accordingly, the large-plan wedge design was frozen for Road production in December 1948.

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More intensive testing in mid-1950 revealed that bomb instability could occur when the Mk 4 was released at altitudes of 26,000 to 31,000 feet, and it was recommended that releases be made above or below this range.[32] It was theorized that this instability was caused by the development of a large shock wave near the fins and the use of circumferential spoiler bands to create smaller shock waves at the mid-point of the bomb and prevent formation of this one large shock wave, was suggested.[33] Tests subsequently made in the Wright Field wind tunnel showed that the Mk 4 shape with five of these spoiler bands possessed good stability.[34] These wind-tunnel tests were the last performed on the Mk 4 weapon, as it was felt more logical to apply the spoiler bands to the approaching Mk 6 Bomb rather than to retrofit them to the Mk 4.[35] As a result, all ballistic testing on the Mk 4 Bomb came to an end.

case. The center "belly band" section was split at the top so that it could be spread apart with assembly tools and slipped over the sphere flanges for positioning over the center section of the sphere. Tension bolts pulled the split-band together at the top. A large rubber gasket sealed the surfaces where the steel case met the aluminum sphere case. The forward case supported the antenna nose plate, which could be removed for access to the sphere. The inflight insertion gear was supported by the forward case. The four fins, which were of aluminum sheet-metal construction, were bolted to the rear case.

(b)(3)

The cartridge structure supported the fuzing components, was cylindrical in shape, and used riveted aluminum sheet-metal construction. The X-unit was bolted to the forward end of this assembly, and the entire unit was fastened to the bomb sphere case by bolts through the X-unit flange. Shelves and mounting plates were provided in the cartridge structure for installation of fuzing components.

The fuzing and firing system contained the same general components used in the Mk III Mods 1 and 2, but were mounted in a single cartridge structure. The X-unit used the same basic electrical design as that of the Mk III, but was redesigned to reduce size and weight, and to adapt it to the cartridge structure.

The four radar antennas had cavity-backed slot designs and were mounted on a nose plate at the front of the bomb. Being flush with the outer surface of the weapon, these were superior from the aerodynamic and handling standpoints to the Yagi-type antenna used on the Little Boy and Mk III Bombs.

The clock timers and batteries were provided with heated, insulated covers to protect against freezing during flight to the target. These heaters were powered from the aircraft electrical system through a cable connection at the upper surface of the rear case which was separated when the bomb dropped away from the aircraft. This same pullout cable was used during flight to monitor the electrical components in the bomb.

The "Archie" radars were modified APS-13 "Tail Warning Charlie" radars developed during World War II. They were adapted to the bomb fuzing application by using a different antenna system and modifying the range gate. (b)(3) The early radars required alteration by soldering iron to change the range setting, but later modifications provided plug-in gate lines.

(b)(3)

(b)(1), (b)(3)

The following aircraft were equipped to deliver the Mk 4. For the Air Force; B-29, B-36D, B-36F, B-47B, B-50A, and B-50D. For the Navy; AJ1 and AJ2. Since the Mk 4 was originally designed for carriage by B-29 and similar land-based aircraft, no provision had been made for resisting catapult loads. With the development of Navy aircraft capable of taking off with the bomb from the deck of an aircraft carrier, some difficulty at the sway-brace locations was encountered. This was overcome by redesigning the sway braces in the aircraft bomb bay so as to distribute the load over a sufficient area to prevent damage to the outer case of the Mk 4.

The Mk 4 Mod 0 Bomb entered stockpile March 1949. It was not equipped for inflight nuclear insertion. It included the Type C pit and had an inflatable rubber gasket to seal the ballistic case. Baro ports were located at the nose of the bomb, and the entire interior of the bomb case was used as a "plenum chamber" to provide static pressure to the baroswitches.

The "Mod-Alt" change system was not in use at this time, and major changes were processed under a "block" change system. All weapons in a given "block" of units incorporated the same changes. In May 1950 the Mk-Mod-Alt weapon designation system was instituted, and the weapon was divided into three major assemblies, bomb, fuze, and capsule.[42] The bomb capable of inflight nuclear insertion became the Mk 4 Mod 1 (previously identified as the Block 7 weapon). It also included a solid rubber gasket for sealing the ballistic case. Since it had a Type C pit, the complete bomb nomenclature was Mk 4 Mod 1-C.

The Mk 4 Mod 2-C Bomb incorporated a baro manifold, which was a circular copper tubing assembly installed in the rear ballistic case.[43] Static pressure was provided from intake ports in the rear cover plate through flexible hose leading to the manifold and additional flexible hose connected the manifold to the baroswitches. The accuracy of the baro system was improved by this change, since it no longer depended on a sealed ballistic case for a static pressure source.

The Mk 4 Mod 2-D Bomb incorporated a Type D pit with a higher yield.[44] Special handling equipment was required for insertion of this capsule into the pit, and included a loading tool and a capsule alignment tool or loading trough. By the end of 1951, all Mk 4's had been retrofitted to the Type D pit.[45]

The Mk 4 Mod 3 Bomb incorporated a lightweight magnesium antenna nose plate for easy manual handling. This permitted simplification of the inflight nuclear insertion gear and speeded the operation. Since this change was incorporated on bombs having either the Type C or D pit, it was identified as the Mod 3-C or Mod 3-D.

The "cartridge" became, under the new system, the Mk 4 Mod 1 Fuze. This included the AR-10A "Archie" radars (four required), BS-4 or BS-5 Baroswitches (six required), M-127 "clock" timers (eight required), Mk 4 X-unit, and lead-acid ER-12-10 batteries. The components were mounted on an aluminum structure for convenient installation.

(b)(3)

interval before supplying power to the firing set. This time interval allowed the airplane to get beyond radar fuzing range, preventing premature detonation by radars ranging off the aircraft. Closing of the arming switches by the clocks allowed current from the 30-volt battery packs to flow through the X-unit choke and the closed firing switch. This current flow caused a magnetic field to be built up in the choke.

At a predetermined altitude, well above the desired burst height, baroswitches closed, allowing the radars to start transmitting and receiving. At the preset burst height, the ranging of any two of the four radars off the target operated a relay network which opened the firing switch in the X-unit. The rapid opening of this firing switch caused a collapse of the magnetic field in the choke, transferring electrical energy to a condenser. When the voltage in the condenser built up to approximately 4000 volts, the spark-gap switch spontaneously broke down, allowing current to flow through the gap and the detonator circuits.

Bridge wires in the detonators were vaporized by the high-voltage pulse. This detonated the explosive material in the detonators, which in turn ignited the high-explosive charges of the sphere, creating a spherically convergent detonation wave which compressed the nuclear components to supercriticality.

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Chapter V - Mk 4 Improvement

After the Mk 4 entered stockpile, design improvements continued despite the fact that much of the engineering staff was transferred to work on other weapons. A list of desirable modifications was compiled, based on a joint military-Sandia survey, and, after thorough review, was formally issued May 18, 1949, under the title "Desired Military and Technical Characteristics of FM Type Atomic Weapons."[48]

Five areas were listed, including weapon battery, ballistics, inflight nuclear insertion and extraction, lightweight case, and improved fuzing system. Battery improvement, due to the state of the art, was deferred for later consideration; the ballistics story has been developed in Chapter III.

The inflight nuclear insertion and extraction project was already well under way, as studies had started in early 1948,

(b)(3)

Facilities for supporting the antenna nose plate and sphere access door while the nuclear capsule was being guided into position were also provided. This support device was temporarily bolted to the nose of the bomb while it was in the bomb bay of the aircraft proceeding to target, and was manually operated.[18] A later production version eliminated the support arms for the nose plate and access door, which by that time had been much reduced in weight.

(b)(3)

It was originally felt that the Mk 4 should be protected against flak by an outer case of 1/4-inch-thick armor plate. Those attending the August 25, 1945, meeting that discussed general bomb features had felt that this protection was unnecessary,[22] and as a result the weapon was constructed with a case of 3/8 inch-thick mild steel. The Bureau of Ordnance later noted that aluminum offered somewhat better protection than steel, when equal weights of materials were used, and as a result some reduced-scale aluminum cases of 3/4-inch thickness were designed, built, and drop tested in 1947. However, the fact that strong steel cases were normally used in bomb construction led the Mk 4 designers back to this material.

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This topic was mentioned in the September 30, 1948, meeting of the Sandia Research and Development Board, with Sandia pointing out that the change would necessitate a major change in material sources, tooling, and bomb handling equipment, and that a thorough stress analysis would be required.

Subsequently, considerable correspondence on the subject developed between the Division of Military Application, Military Liaison Committee, AEC, and Sandia, with efforts being made to determine whether or not there was a real need for the heavy case for either flak protection or storage.[53,54,55,56] On December 24, 1948, Sandia informed AEC that a development program for reduction of Mk 4 Bomb weight had been established at Project Roger (the Army's Rock Island Arsenal, which was handling certain weapons production work) and its subcontractor, the American Car and Foundry Company. The purpose of this program was to evaluate and recommend weight reductions based on an aluminum outer case produced by the same tools used for forming the steel casing.[57]

Meanwhile, various pressures were exerted both for and against the design of a lightweight case,[58,59,60] with the matter being decided February 17, 1949, when the Division of Military Application directed Sandia to subcontract the design of an aluminum case.[61] On March 16, Northrop Aircraft, Inc., was invited to design a riveted case,[62] and in May the American Car and Foundry Company was asked to design a welded case.

Ballistic testing of both the riveted and welded cases was conducted in December 1949, and static and dynamic tests were run at Wright Field.[63] These proved that both cases were satisfactory, and, inasmuch as cost and weight comparisons were roughly equivalent, it was decided to procure both types.[64,65,66,67] Production of the riveted design was turned over to Project Royal (the AEC manufacturing facility at Kansas City), and the

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Meanwhile, it was becoming evident that the lightweight case and the improved fuze could be put into production simultaneously, and in July 1950 a high-priority or "crash" program called 4-N was established. (b)(3)

Shortly thereafter, however, it was decided to treat the modified Mk 4 as an entirely new weapon, and the program evolved into the Mk 6.

Design attention was also given to improving the pressure-operated or barometric switch which "armed" or placed the radar in operational condition. The original approach had been to consider the interior of the bomb as a plenum or pressure chamber and to measure the pressure as the bomb fell through the air toward the target. Vent holes to the external atmosphere were located in the nose of the bomb, and it became necessary to provide an airtight seal between the sections of the bomb case.

It was at first thought that an inflatable rubber tube would serve for this seal,[74] but it was found impossible to maintain air pressure in this tube. In addition, the relatively large volume of the plenum chamber made it difficult to secure rapid responses to changes in external air density, and it was decided to substitute a small-volume manifold constructed from a length of tubing bent into a circular shape and installed under the contour of the bomb skin near the tail. Because of the possibility of the nose ports becoming plugged with ice,[75] they were relocated in the tail plate.[76]

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Implosion-Type Bomb -- A weapon based on the principle discovered by Professor Charles E. Munroe, Washington, D. C. Written up by him in Scribner's Magazine and the American Journal of Science in 1888 and in Popular Science Monthly in 1900. Rediscovered by Egon Neuman of Germany, who secured German and English patents in 1910-11. The Munroe principle notes that an increased explosive effect is created when an unconfined cylinder of high explosive is hollowed out. In 1920 the Journal of the Society of Chemical Industry (London) stated that "no practical use has apparently been made of this discovery." Suggested by S. H. Neddermeyer at Los Alamos as a means for producing the extremely high pressures required on the capsule of an atomic bomb. Not much attention was paid to the suggestion until it received the backing of John von Neumann and George Kistiakowsky. The same principle was used in the Pacific area in World War II as a means of destroying Japanese pillboxes, and for increasing the penetrating effect of rockets.

Kiloton Yield -- A means of measuring the effect of a nuclear explosion by comparing it with the effect of an explosion of TNT. One-kiloton yield is equivalent to the effect of 1000 tons of high explosive.

Kirtland Field -- An Air Force Base located in Albuquerque, New Mexico, and using part of the facilities of the Municipal Airport (Sunport). Kirtland Field was built in 1939 with the help of federal funds. Named for Colonel Roy F. Kirtland, one of the earliest Army aviators.

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Manhattan Engineer District -- A district of the Army Corps of Engineers established in August 1942 under the command of General Leslie R. Groves to develop weapons using atomic energy.

Military Liaison Committee -- A committee established by the Atomic Energy Act of 1946 to advise and consult with the AEC and on behalf of the Department of Defense, on all atomic-energy matters relating to military applications of atomic weapons. Chairman can be any active or retired officer of the Armed Forces. Includes a representative or representatives from each Department of the Armed Forces.

Operation Crossroads -- See Crossroads.

Operation Greenhouse -- See Greenhouse.

Operation Sandstone -- See Sandstone.

Oxnard Field -- Constructed in 1929 as the airport for the City of Albuquerque by Frank G. Speakman. Named Oxnard Field in 1931 for James G. Oxnard, who financed its expansion and who was its owner until May 1942, when the area was taken over by the Government for an Air Depot Training Station.

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Radars -- See Archies. Named for RAdio Detecting And Ranging.

Salton Sea Test Base -- Located on the site of a Naval Auxiliary Air Station on the shores of Salton Sea, California. Acquired in June 1946 for ballistic tests of the Z Division.

Sandia Base -- Located east of the City of Albuquerque and adjoining Kirtland Field. Encompasses the area formerly occupied by Oxnard Field, plus additional land extending south to the Isleta Indian Reservation and east to the Manzano Mountains. Operated under the tripartite control of the Armed Forces Special Weapons Project.

Sandia Laboratory -- An outgrowth of the Los Alamos Laboratory's Z Division. Originally established as Sandia Branch of LASL; in November 1949 it became an independent entity, Sandia Corporation, with a contract with the AEC and under the managerial direction of the Western Electric Company.

Sandia Research and Development Board -- A joint Sandia Laboratory-military board formed at Sandia Base to provide local guidance on weapons design.

Sandstone -- Full-scale test operation held in the Pacific in April 1948.

Tactical and Technical Liaison Committee -- A committee of Air Force officers established to provide liaison between the atomic project and the Air Force prior to admittance of the Air Force as a member of the Armed Forces Special Weapons Project.

Telemetry -- The science of radio transmission of information to a ground station from an object traveling in space.

Wendover Field -- Located in Utah, west of Salt Lake City. A training location for the Army Air Forces work with wartime atomic bombs.

W-47 Flight Test Group -- The Army Air Forces group stationed at Wendover Field during World War II. Part of this group was transferred to Kirtland Field after the war and helped in the bomb drops at Los Lunas.

Yagi -- A radar antenna developed by a Japanese scientist.

X-Unit -- ~~A high-voltage transformer~~ A device used to provide high voltage ~~to the~~ weapon detonators.

Z Division -- A Los Alamos Laboratory division established in July 1945 to handle development work on atomic bombs. Part of the Z Division was moved to Sandia Base at the close of the war, and became the nucleus of Sandia Laboratory. Named for Jerrold Zacharias, first leader of the Division.

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References

1. SRD Ltr, RS SMD-12, E. L. Cheeseman to All Groups Concerned, dtd 7/7/47, subject, Nomenclature Conference. SC Archives, microfilm reel 700.

2. SRD Ltr, J. R. Zacharias to J. R. Oppenheimer, dtd 8/6/45. LASL Files, 310.1 Z Division.

3. SRD Ltr, Frank Oppenheimer to All Concerned, dtd 8/8/45. Appendix to Report SLE-(830). SC Archives.

4. SRD Minutes, dtd 8/29/45, subject, Proposed Plan for Activation of Z-II Group at Sandia. LASL Files, 322 Sandia 2/1/45-12/31/49.

5. SRD Ltr, Capt. R. D. Larkin to Comdr. William S. Parsons, dtd 9/7/45, subject, Organization of Z Division. LASL Files, 310.3 Org - Parsons.

6. SRD Reports, RS SMD-601, Z Division Supervisors to J. R. Zacharias, subject, Progress Covering Period September 1945 to December 1946. SC Archives, microfilm reel 700.

7. SRD Ltr, Dale R. Corson to File, dtd 9/25/45, subject, Discussion at Wright Field on Aircraft to Carry Atomic Bombs. SC Archives, microfilm reel MF-SF-SC-12.

8. SRD Ltr, Roger S. Warner, Jr., to Norris E. Bradbury, dtd 11/29/46. LASL Files, 471.5 Mark IV.

9. SRD Report, LAMS-544, subject, Z Division Status Report for February 1947. SC Archives, microfilm reel 700.

10. SRD Ltr, B. H. Shaffer to All Concerned, subject, Minutes of Meeting on Mk IV Held 16 April 1947. SC Archives, microfilm reel 700.

11. SRD Ltr, RS 3466/27599, R. W. Henderson to N. E. Bradbury, dtd 11/25/47, subject, Congressional Report. SC Archives, microfilm reel MF-SF-SC-11.

12. SRD Ltr, Norris E. Bradbury to Paul J. Larsen, dtd 11/20/47. SC Archives.

13. SRD Minutes, RS 3466/60052, Sandia Research and Development Board to Distribution, 2nd Meeting, dtd 3/12/48. SC Archives.

[redacted]

UNCLASSIFIED

14. SRD Ltr, Col. Howard G. Bunker, Technical and Tactical Liaison Committee to Chief of Staff, US Air Force, dtd 3/26/48, subject, Extraction and Insertion of Nuclear Capsule with Mk IV Bomb Suspended in Bomb Bay. Air Force Special Weapons Center Files, T&TLC 1946-1948.

15. SRD Minutes, RS 3466/60127, Sandia Research and Development Board, 7th Meeting, dtd 7/20/48. SC Archives.

16. TSRD Report, Air University Historical Liaison Office, dtd 1960, subject, The History of the Air Force Participation in the Atomic Energy Program, 1943-1956. Air Force Special Weapons Center Files.

17. SRD Minutes, RS 3466/50124, Sandia Research and Development Board, 6th Meeting, dtd 5/6/48. SC Archives.

18. (b)(1), (b)(3)

19. SRD Report, RS 3466/33041, Sandia Corporation to Distribution, subject, SL-11, Monthly Progress Report 11/18/48-12/18-48. SC Archives.

20. SRD Report, RS 3466/33076, Sandia Corporation to Distribution, subject, SL-71, Monthly Progress Report 1/18/49-2/18/49. SC Archives.

21. SRD Report, RS 3466/33080, Sandia Corporation to Distribution, subject, SL-79, Monthly Progress Report 2/18/49-3/18-49. SC Archives.

22. SRD Report, RS SLE-(830), Sandia Corporation to Division of Military Application, dtd 11/26/48, subject, Interim Report on Ballistic History of Mark IV FM Bomb. SC Archives.

23. SRD Ltr, Dale R. Corson to Capt. T. O. Jones, dtd 10/1/45, subject, Use of Bombing Range. SC Archives, microfilm reel MF-SF-SC-13.

24. CRD Ltr, RS SMD-13, C. E. Runyan and L. H. Cherry to Z Division Group Leaders, dtd 7/26/46, subject, Review of Z-4 Ballistic Test Program. SC Archives, microfilm reel 700.

37. SRD Report, RS SL-82, Final Evaluation Report, Mk IV Mod 0 FM Bomb, dtd 9/13/49. SC Reports Library.

38. (b)(1), (b)(3)

39.

40. SRD Report, RS SWC 7S-1, The Special Weapons Center and Atomic Testing, dtd 1/57. Air Force Special Weapons Center Files.

41. (b)(3)

42. SRD Report, RS SC1448(PL), Basic Parts List for the Mark IV Mod 1-C Bomb, dtd 5/25/50. SC Central Technical Files.

43. SRD Report, RS SC1474(PL), Basic Parts List for the Mk 4 Mod 2-C Bomb, dtd 6/23/50. SC Central Technical Files.

44. SRD Report, RS SC1997(PL), Basic Parts List for the Mk 4 Mod 2-D Bomb, dtd 8/27/51. SC Central Technical Files.

45. SRD Report, RS SC2299(S), Analysis of the AEC Mk 4 Stockpile as of 12/31/51, dtd 4/52. SC Central Technical Files.

46. (b)(3)

47. (b)(3)

48. SRD Report, Armed Forces Special Weapons Project to Distribution, dtd 5/18/49, subject, Desired Military and Technical Characteristics of FM Type Atomic Weapons. SC Archives, microfilm reel MF-SF-SC-29.

49. (b)(3)

50. (b)(3)

77. SRD Minutes, RS 3466/60140, Sandia Research and Development Board to Distribution, 10th Meeting, dtd 9/30/48. SC Archives.

78. SRD Report, RS 3466/25061, Sandia Corporation to Distribution, subject, SC1346, Monthly Progress Report January 1950. SC Archives.

HISTORY OF THE MK 5 BOMB

The feasibility of creating a small implosion bomb was one of the weapon concepts studied by the Los Alamos Scientific Laboratory after the end of World War II. The over-all size of the wartime Fat Man device (which was to be as large as possible) had been established by the dimensions of the B-29 bomb bay and the existing state of implosion theory, and the resulting weapon was a bomb with reasonably high nuclear efficiency, but which was difficult to handle due to its bulk and weight (60-inch diameter; 128-inch length; 10,900-pound weight). Consequently, calculations were made of compressions produced by small-diameter high-explosive spheres, and different arrangements of nuclear material were studied.

This small implosion design was of interest to the Military, and the Military Liaison Committee informed the Atomic Energy Commission October 31, 1947, that current implosion bombs did not lend themselves to wide or flexible employment, and that a weapon both lighter and smaller than the Mk 4 (then in design) would be of considerable military importance.[1] The Atomic Energy Commission, in replying to this letter on December 10, 1947, pledged support of a vigorous program to develop a small bomb.[2]

Meanwhile the Division of Military Application wrote to Santa Fe Operations Office November 25, 1947, noting that any reduction in bomb weight would result in an increased range of the carrying aircraft and pointed out that: "Reduced dimensions might open up an entire new field of flexibility in the employment which could be a decisive influence in the military capability of getting the bombs home in war." However, it was noted that the Los Alamos effort on Operation Sandstone (to be held in the Pacific during the summer of 1948 to test new nuclear designs) might delay starting work on the new weapon.[3]

During 1948, it became apparent that determination of size, shape and weight for the lighter and smaller weapon required an understanding of military aircraft, delivery plans and problems. A conference was consequently held at Los Alamos September 2 and 3, 1948, which was attended by representatives of the Military, AEC weapon laboratories, and cleared members of the aircraft industry. It was decided that a bomb with a diameter of 40 to 48 inches and weighing between 5000 and 6000 pounds would cause significant improvement in aircraft performance and increase the probability of successful weapon delivery. It was felt that the length of the weapon should be retained at 128 inches.[4]

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During the foregoing study period, the project had been known as the Small Weapon Program and was directed by the Los Alamos Committee for Weapon Development. It was subsequently transferred, October 11, 1948, to the W (Weapon Development) Division of Los Alamos with the request that this Division undertake an "experimental, calculational, and fabrication program aimed at the production of a specific model of a complete small weapon for test early in 1951."[6]

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The work of the W Division almost immediately involved the Sandia Branch of the Los Alamos Scientific Laboratory and, it was suggested that a Steering Committee be established to direct development work on the weapon.[7] This new group initially met November 3, 1948, and the Chairman noted that much confusion had previously arisen due to various terms used to identify a given weapon, and suggested that a standard weapon name as well as a designation for the Steering Committee be established.[8] Mk IV nomenclature had already been assigned, so it was logical to use the next number, Mk V, for this device. The Committee felt, however, that development models of the weapon should be specifically identified, and it was decided to use the letter "X" as a prefix to show the experimental nature of the design. It was also decided to add the letter "T" to indicate--in the phraseology of the Committee's minutes--"the word 'tentative' or 'tiny' (or something)." Thus the weapon became known as TX-V (and, soon thereafter, the TX-5) and the Committee as the TX-5 Steering Committee. The adoption of this system set the pattern for many subsequent atomic devices.[9]

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The possibilities of contact or even subsurface burst requirements were briefly considered, but it was felt that the basic design of an implosion weapon made anything but air burst impossible.

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Computer time was scheduled, and it was hoped to have compression figures in about 3 months.[10] (Subsequently, due to the pressure of other computer programs, it was decided to interpolate, using other computational results.) The Steering Committee established a schedule calling for preliminary design by January 1, 1950, and complete design July 1, 1950. (b)(3)

The contents of a December 10, 1948, letter from the AEC General Advisory Committee were discussed in the January 7, 1949, meeting of the TX-5 Steering Committee. This letter stated that reduction of size and weight of atomic weapons was vitally important to national defense and that the AEC wholeheartedly supported the aims of the Steering Committee in this regard. The Advisory Committee hoped that the new small weapon could be ready for production soon after proof-firing, and suggested that a substantial portion of the implosion stockpile in early 1950 be made up of the new bomb. The program was accordingly accelerated.[12]

Problems of nuclear safing had meanwhile been studied. The Sandia Research and Development Board (later renamed Sandia Weapons Development Board and, still later, Special Weapons Development Board) was a group including representatives from Sandia and the Armed Forces Special Weapons Project, the military organization formed to handle military problems connected with the atomic bomb. The Board held an initial meeting March 2, 1948, and suggested that design attention be paid to the possibility of extracting the nuclear capsule of an atomic bomb while it was being carried to the target. This action would prevent nuclear detonations caused by a landing accident, should the mission be aborted or the plane return to base with weapon unexpended.[13]

The Tactical and Technical Liaison Committee, established by the Air Force to provide atomic liaison, had suggested, March 26, 1948, that both extraction and insertion in flight would increase aircraft and airport safety, and reduce nuclear contamination caused by accidents during takeoffs or landings.[14] (b)(3)

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The next step was to design some type of capsule handling device, and this became known as an inflight insertion mechanism. The device initially was manually operated, but this operation was awkward due to lack of room in the bomb bay, and the fact that the aircraft had to fly at low altitudes during insertion or extraction. (The bomb bay was not pressurized, and personnel operating the equipment would have been handicapped if required to wear oxygen masks.) An automatic and remotely controlled mechanism was accordingly designed.

Consideration was given to the necessity for duplicate bridge wires in each detonator. (b)(1), (b)(3)

The use of single bridge wires was then proposed, with two X-units connected in parallel to each bridge wire. This raised the question as to whether one X-unit would fire back through the other, rather than across the bridge wires, and it was eventually decided to provide one highly reliable X-unit and to use single bridge wires.

Initial Sandia mention of the new weapon was made in a progress report of February 18, 1949, wherein it was noted that SLE-7 had been organized as the FM Mk V Division.[18] This Division, in starting design work, was confronted with the general shortage of office and engineering space and facilities at Sandia, caused by the concurrent startup or expansion of other design projects.

Selection of aircraft to carry the TX-5 was discussed in the Steering Committee meeting April 8, 1949. The Air Force program was currently slanted toward use of heavy, long-range bombardment aircraft. Medium-size Navy bombers were still under design, and would not be in production for at least 2 years. Consequently, there was some feeling that current schedules might produce a new bomb before a suitable bomber became available.[19]

As a result of the above meeting, a TX-5 Ad Hoc Panel was appointed by the Military Lisison Committee May 12, 1949.[20] (b)(1), (b)(3)

It was agreed that as small a diameter as practicable should be selected, since it would be relatively

> "The TX-5 project is one of the weapon developments in which the interest of the Atomic Energy Commission reflects a general concern that within the next few years the problem of successful delivery of atomic weapons may come to overshadow the problem of increasing the destructive potential of the weapons themselves. The Commission recognizes the primary responsibility of the using forces to set forth desired technical characteristics of weapons, as these characteristics bear on the delivery problem. The Commission remains anxious, however, that its best technical effort be contributed to a solution of this problem in all of its variants which impinge in the area of the Commission's responsibility. The Commission will therefore continue to keep you fully informed of prospective reductions in weapon size and weight, hoping that full advantage will be taken of these forecasts to ease the problems of development of future carriers, a field in which the development cycle is of course substantially longer than the usual cycle of development of the associated weapons."[22]

The Military Liaison Committee wrote to the Division of Military Application February 9, 1950, noting their belief that large-implosion-bomb performance could be considerably improved through use of nuclear design improvements produced by the TX-5 work, and stating that the smaller bomb should be reserved for use in guided missiles. The Committee proposed that a decision on TX-5 production be made after the 1951 tests, and stated that it appeared inadvisable at this time to freeze design on a production TX-5 or to plan for any substantial stockpiling.[23] The Division of Military Application stated, in a reply dated March 30, 1950, that the TX-5 nuclear design improvements might obviate any need for larger bombs, but agreed that higher priority would be assigned to use of the TX-5 with future guided missiles.[24]

The cumulative effect of the above correspondence might have redirected the TX-5 program, if the international situation had not intervened. The increasing pressures of the cold war and eventual outbreak of the Korean conflict caused an acceleration of national defense plans and programs, and resulted in a May 10, 1950, visit to Los Alamos by the Director of the Division of Military Application. This visit was discussed in the May 26, 1950, meeting of the TX-5 Steering Committee, in which it was noted that it would be necessary to "pick up a few months or even a year" in TX-5 production.[25] Subsequently, a teletype was received July 11, 1950, from Washington AEC which, in part, stated: "Anticipating a Military requirement not yet firm you are directed to formulate a plan using all facilities at your disposal to deliver to War Reserve at the earliest possible date service models of TX-5."[26]

The schedule that Sandia subsequently prepared established a target date of January 1, 1952, for Mk 5 production. Quantity requirements were authorized in a Military Liaison Committee directive of September 14, 1950, and these figures were revised upward December 18. The Atomic Energy Commission urged all possible speed and noted that:

> "Certain procedures may be warranted at this time that would otherwise not be undertaken until the weapon characteristics were more completely defined. There is an obligation on us all to economize in both effort and money by identifying promptly the areas of uncertainty and pressing for their resolution. There is an equal obligation, however, to take action as necessary to maintain the best possible schedule, even at the risk of occasionally involving ourselves in unproductive ventures."[27]

unlatched during final assembly or postloading tests.[36] / (b)(1), (b)(3)

The low-burst cables were temporarily withdrawn, testers modified, and the low-burst capability restored in April 1952.

The Mk 5 Mod 0 Bomb was discussed in the August 6, 1952, meeting of the Special Weapons Development Board. It was noted that contact resistance of the baroswitches increased with age, but that this could be corrected by cleaning the contacts with solvent, changing the insulating material to eliminate an outgassing problem, and using gold alloy contacts. The inflight insertion mechanism had a tendency to overshoot and cause excessive wear, and a slipping clutch was added to correct this difficulty. The Board accepted the weapon for stockpiling, since corrective action was being taken on these items.[37]

The Mk 5 Mod 1 Bomb resulted from an Armed Forces Special Weapons Project request that cables to supply external power to heaters for batteries and radars be provided to maintain these items at operating temperature in cold weather. Stockpile production of the Mk 5 Mod 1 started November 1952.[38]

On October 13, 1953, Sandia suggested that the inflight insertion mechanism of the Mk 5 Bombs be reworked to incorporate all design changes that had been proposed in this apparatus. At the same time it was suggested that the cartridge mounting be altered to allow a bomb-to-warhead conversion capability, and this proposal was accepted. Design release was effected November 1953 and the revised weapon stockpiled in June 1954 as the Mk 5 Mod 2 Bomb.[39]

A considerable change to the Mk 5 Bomb was made in the Mod 3, which incorporated a new fuze. General dissatisfaction with the complexities of a radar fuze had caused Sandia to examine other methods, and an intensive study of this subject was instituted in mid-1951.[40] The simplest system would have been a pure barometric fuze, but this design had large inherent inaccuracies.[41] An impact fuze offered many advantages, including that of destruction of the bomb in the event the regular fuze failed, and much effort was expended on this device. This required the use of a fast-firing X-unit, and suitable design work was instituted.[42]

By the fall of 1952, a four-option fuzing system was being studied for Mk 5 application. This system included baro primary, radar primary, timer primary, and contact. Contact backup would be provided for the three air-burst options. The fuzing option would be selected during weapon assembly, through an access port in the skin of the bomb, by insertion of the proper plug in the top of the junction box.

A report on the above proposal was made to the Special Weapons Development Board September 10, 1952. Some members of the Board felt that remote selection of the fuzing option should be possible from the bomber while the weapon was being carried to the target, and other Board members requested that Sandia study the possibility of providing a fifth option, that of a baro-armed radar fuze.[43]

A proposal for a modification of the Mk 5 with the above five fuzing options, together with a suitable fast-firing X-unit, was forwarded to the Division of Military Application on October 22, 1952, and subsequently referred to the Military Liaison Committee.[44] The Committee, in their review of the proposal, requested deletion of the radar fuzing option and asked that inflight selectability be provided for the baro, timer and contact options. This requirement was discussed at the December 10, 1952, meeting of the Special Weapons Development Board, and it was agreed that the new fuze could be designed by May 1953.[45]

In the meantime, the concurrent development of many different fuzes for various weapons had generated concern, within both Sandia and the Armed Forces Special Weapons Project. By January 15, 1953, five such fuzes were currently under design for the Mks 5, 6, 7, 12 and 13. These fuzes required 30 different pieces of support equipment, and it was felt that this proliferation of gear would complicate training, operations, and

References

1. SRD Ltr, Military Liaison Committee to Atomic Energy Commission, dtd 10/31/47. AEC Files, 471.6.

2. SRD Ltr, Atomic Energy Commission to Military Liaison Committee, dtd 12/10/47. AEC-DMA Files, Germantown, Maryland. Mil Res & Appl, Vol I, 10/47-6/49, Mk 5.

3. SRD Ltr, Division of Military Application to Santa Fe Operations Office, dtd 11/25/47, subject, Weapon Development. AEC-DMA Files, Germantown, Maryland. Mil Res & Appl, Vol I, 10/47-6/49, Mk 5.

4. SRD Report, RS 3446/62284, Division of Military Application to Distribution, dtd 7/19/51, subject, Production and Stockpiling of the Mk 5 Atomic Bomb. SC Central Technical Files, Mk 5.

5. (b)(3)

6. SRD Ltr, Los Alamos Scientific Laboratory to Steering Committee, dtd 10/11/48. Los Alamos Files.

7. SRD Ltr, RS 3466/97058, Los Alamos Scientific Laboratory to Distribution, dtd 10/26/48, subject, First Meeting of Steering Committee for Small Weapon Program. SC Archives, microfilm reel MF-SF-SC-68.

8. SRD Report, Los Alamos Scientific Laboratory to Distribution, dtd 11/3/48, subject, Matters for Consideration for First Meeting of Smaller Weapon Steering Committee, SC Archives, microfilm reel MF-SF-SC-68.

9. SRD Minutes, TX-V Steering Committee to Distribution, dtd 11/3/48, subject, Minutes of the First Meeting. SC Archives, microfilm reel MF-SF-SC-68.

10. SRD Minutes, TX-V Steering Committee to Distribution, dtd 11/10/48, subject, Minutes of the Second Meeting. SC Archives, microfilm reel MF-SF-SC-68.

11. (b)(3)

12. SRD Minutes, TX-5 Steering Committee to Distribution, dtd 1/7/49, subject, Minutes of the Fourth Meeting. SC Archives, microfilm reel MF-SF-SC-68.

26. SRD TWX, Division of Military Application to Santa Fe Operations Office, dtd 7/11/50. SC Archives, microfilm reel MF-SF-SC-28.

27. SRD Ltr, Santa Fe Operations Office to Los Alamos Scientific Laboratory and AEC Field Manager, Sandia Base, dtd 7/28/50, subject, Production of Mark 5 Weapon. SC Archives, microfilm reel MF-SF-SC-28.

28. SRD Report, Sandia Laboratory to Distribution, dtd 6/18/49, subject, Monthly Progress Report May 18, 1949 to June 18, 1949. SC Archives, microfilm reel MF-SF-SC-130.

29. SRD Report, RS 3466/26619, Sandia Corporation to Distribution, dtd 5/13/55, subject, SC3622(TR), A Summary of Sandia Corporation Field Testing of Development Atomic Weapons. SC Reports Files.

30. CRD Ltr, RS 1000/1275, Sandia Corporation to Air Force Special Weapons Center, dtd 3/27/53, subject, Summary of TX-5 Separation Characteristics from the B-47 Aircraft. SC Archives, microfilm reel MF-SF-SC-1440.

31. SRD Minutes, RS 3466/72451, Special Weapons Development Board to Distribution, dtd 9/1/54, subject, Minutes of 85th Meeting. SC Archives, Transfer No. 48217.

32. CRD Ltr, RS 2000/107, Sandia Corporation to AEC Field Manager, Sandia Base, dtd 4/26/51, subject, Mark 5 (TX-5). SC Archives, microfilm reel MF-SF-SC-1440.

33. SRD Minutes, RS 3466/60831, Sandia Weapons Development Board to Distribution, dtd 6/27/51, subject, Minutes of 52nd Meeting. SC Archives, microfilm reel MF-SF-SC-101.

34. SRD Ltr, TX-N Steering Committee to Sandia Corporation and Los Alamos Scientific Laboratory, dtd 6/12/51, subject, Design Release of the Mk 5 Mod 0 Weapon. SC Archives, microfilm reel MF-SF-SC-28.

35. SRD Ltr, RS 1000/470, Sandia Corporation to Armed Forced Special Weapons Project, dtd 7/28/51, subject, TX-5 Assembly Operations. SC Archives, microfilm reel MF-SF-SC-79.

36. SRD Ltr, Sandia Corporation to Armed Forces Special Weapons Project, dtd 1/17/52, subject, Circuits Involving the Mk 5 Mod 0 Fuze with Low Burst Option and the T-20 and T-21 Testers. SC Archives, microfilm reel MF-SF-SC-64.

37. SRD Minutes, RS 3466/67306, Special Weapons Development Board to Distribution, dtd 8/6/52, subject, Minutes of 65th Meeting. SC Archives, Transfer No. 48217.

38. SRD Ltr, Military Liaison to Test Equipment Departments, both of Sandia Corporation, dtd 2/18/52, subject, AFSWP Requirement for Warm-Up Cable. SC Archives, Transfer No. 44851.

39. SRD Ltr, Sandia Corporation to AEC Field Office, Sandia Base, dtd 10/13/53, subject, Nomenclature Changes to the Mk 5 Bomb. AEC Archives, folder M5/1.

✓ 40. SRD Ltr, RS 1200/369, Director of Engineering to Director of Research, both of Sandia Corporation, dtd 7/10/51, subject, Fuzing System for Mk 5 Mod 1 Weapon. SC Archives, microfilm reel MF-SF-SC-28.

✓ 41. CRD Ltr, RS 1121/118, Aerodynamics Division to Weapons Component Department, both of Sandia Corporation, dtd 9/21/51, subject, Baro Pressure Sensing on the TX-5. SC Archives, microfilm reel MF-SF-SC-28.

42. SRD Case Authorization, TX-5-X1, dtd 2/15/52. SC Archives, microfilm reel MF-SF-SC-64.

43. SRD Minutes RS 3466/67325, Special Weapons Development Board to Distribution, dtd 9/10/52, subject, Minutes of 66th Meeting. SC Archives, Transfer No. 48217.

✓ 44. SRD Ltr, Sandia Corporation to Division of Military Application, dtd 10/22/52, subject, Transmittal of the TX-5-X1 Feasibility Report, SC2503(TR). SC Archives, folder TX5/1, TX5/2.

45. SRD Minutes, RS 3466/67677, Special Weapons Development Board to Distribution, dtd 12/10/52, subject, Minutes of 68th Meeting. SC Archives, Transfer No. 48217.

✓ 46. SRD Ltr, RS 3466/67707, Field Command to Sandia Corporation, dtd 1/15/53, subject, Standardized Fuzing for Implosion Bombs. SC Central Technical Files, F-4, 1953.

✓ 47. SRD Minutes, RS 3466/67734, Special Weapons Development Board to Distribution, dtd 1/21/53, subject, Minutes of 69th Meeting. SC Archives, Transfer No. 48217.

✓ 48. SRD Minutes, RS 3466/67832, Special Weapons Development Board to Distribution, dtd 2/18/53, subject, Minutes of 70th Meeting. SC Archives, Transfer No. 48217.

✓ 49. SRD Report, Sandia Corporation Department 1240 to File, dtd 3/2/53, subject, Progress Report for February 1953. SC Archives.

50. SRD Ltr, Military Liaison Committee to Division of Military Application, dtd 6/4/53, subject, Provision of the TX-7-X1 Fuze on Mark 5 Weapons. SC Archives.

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